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(19)

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(54) IMPROVEMENTS IN OR RELATING TO CUTTING TOOLS

(71) We, PRODUCTION TOOL ALLOY CO. LIMITED, a British Company, of Sharpenhoe, Bedford, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to cutting tools and is particularly directed towards the composition of such tools.

Cutting tools with which the invention is concerned are extensively employed in engineering where it is required to remove a thin layer of material from a workpiece by a wedge-shaped tip or edge driven asymmetrically into the workpiece. Such tools may be in the form of shaped inserts which are intended to be clamped, wedged or otherwise removably secured to a tool holder. Such shaped inserts may be of circular or polygonal form and are generally mounted to be indexible to present a fresh cutting edge or tip to the workpiece as required. In a further form the cutting tool may be a shaped insert or bit which is intended to be metallurgically bonded as, for example, by brazing or otherwise fixedly secured in or on a tool body. In a still further form the cutting tool itself may be of the geometry of a twist drill, rasp or burr. The cutting tools to which the present invention is directed are primarily intended for use on metal workpieces and the following description will be directed to such application.

By way of example, a conventional form of cutting tool and tool holder for it are shown in Figures 1 and 1A respectively in the accompanying illustrative drawings. The cutting tool shown in Figure 1 is a rectangularly shaped insert which is adapted to be secured by clamping in a conventional tool holder as shown in Figure 1A. In use the tool holder is moved relative to a workpiece and the leading wedge-shaped tip of the cutting tool driven asymmetrically into the workpiece to remove a thin layer of material. The workpiece material is removed as a continuous stream of swarf or chips which bears on a top face 1 (generally known as the rake face) of the cutting tool. In the majority of applications of the cutting tool in machine tools, the workpiece will be rotating with respect to the tool and the advancement of the cutting tool tip along the workpiece in inches per revolution is known as "the feed"; the distance between the existing and newly machined faces of the workpiece measured perpendicularly is the depth of cut; the cutting speed of the tool is measured linearly as the length of surface of the workpiece through which the tip is advanced per minute (generally termed "surface feet per minute, s.f.m.") and the face of the cutting tool that bears against the workpiece is known as "the flank", which is indicated at 2 in Figure 1. The flank 2 is inclined to the workpiece at an angle generally known as the clearance angle.

During machining the wedge-shaped tip of the cutting tool is initially positioned to give a small area of contact along the top leading edge of the tool. This area of contact increases by the formation, due to wear, of a new surface, such wear is generally termed "flank wear" and is indicated at 3 in Figure 1. Flank wear is expressed as the perpendicular depth from the rake face 1. As the material of the workpiece is removed, the swarf or chips make contact with the rake face 1 which consequently becomes worn in the form of a pit. This pit is known as the

crater (indicated at 4 in Figure 1) and its perpendicular depth from the rake face is generally referred to as "crater wear measurement". In addition, when using cutting tools of conventional composition, the passage of swarf across the rake face 1 it an elevated temperature frequently results in an effective welding of the workpiece material to the rake face in the proximity of its leading edge. This region of welded material is generally known as a "built-up edge" (as indicated at 5 in Figure 1). The presence of a built-up edge though to some extent protecting the edge of the tip, leads to a significant reduction in general cutting performance and particularly inhibits the generation of good workpiece surface finishes.

As a necessity, the cutting tool must be of a hard material and in general the cutting tool material should possess properties which resist the following conditions:—

a) High compressive stress. The stresses encountered near the cutting edge of a tool are mainly compressive and consequently the yield stress, in compression, of the cutting tool material must be higher than that of the work material for it to function efficiently. Indentation hardness is a good guide to this property. An efficient method of determining the hardness of a material is the Vickers diamond pyramid hardness test by which the hardness of materials is determined by indenting them with a diamond pyramid under a specified load and measuring the size of the impression produced. Such a test is internationally recognised and is fully discussed in publication No. 427 (1961) by the British Standard Institution. The indentor employed is a diamond in the form of a square based pyramid with an included angle between opposite facets of 136° and the hardness of a material is given as Vickers pyramid numerals, which are universally abreviated and hereinafter referred to as V.P.N.

b) Tensile or shear stress. At some positions of the cutting tool high tensile or shear stresses may develop and the breaking strength of the tool in tension becomes an important property.

c) Localised stress concentrations. Stress concentrations, particularly near the cutting edge of the tool increase as the cutting speed, feed and depth of cut increase. Toughness or the ability of the tool to deform locally and absorb energy without cracking is required to contend with these conditions.

d) High temperatures. When cutting workpieces of materials which retain high strength at high temperatures, the temperature at the cutting edge of the tool is particularly high. Similarly as the speed and feed rates increase during cutting of any material so does the temperature at the cutting edge increase. To withstand this, and maintain cutting efficiency, the compressive strength of the cutting tool and its hardness must be retained at these elevated temperatures. Under some conditions oxidation resistance becomes a vital property.

e) Temperature fluctuations. Rapid fluctuation in temperature of the cutting tool, combined with steep temperature gradients, may cause cracking. The property of a cutting tool to resist such thermal fatigue is of considerable importance and consequently both the coefficient of expansion and thermal conductivity of a cutting tool have a marked importance.

f) Abrasion. The resistance of the cutting tool to abrasive constituents in the material of the workpiece is adequately indicated by the hardness of the cutting tool.

g) Diffusion. At high cutting speeds diffusion or reactions between the materials of the cutting tool and the workpiece may control the rate of wear of the cutting tool. The metallurgical relationship between the cutting tool and the material of the workpiece is a property of considerable importance under such cutting conditions.

h) "Built-up edge". The material of the cutting tool should have the ability to withstand the localised stresses caused during machining by the build-up of material from the workpiece on the edge of the cutting tool.

The cutting tools which are at present in general use are of a sintered composition and manufactured by conventional powder metallurgy. The compositions of such cutting tools may be classified as follows:—

1. those containing tungsten carbide and cobalt only;

2. those based on tungsten carbide but containing one or more of the carbides of titanium, tantalum and niobium and bonded with cobalt;

3. those based on titanium carbide and bonded with cobalt, or an alloy of nickel and molybdenum; and

4. the compositions in groups 1 and 2 but in which a surface layer of differing composition is present such surface layer being of, for example, titanium carbide.

Whilst cutting tools of the aforementioned group 1 are generally restricted to machining metals other than steel, it is found in practice that in machining steel or high strength alloys at high cutting speeds currently favoured, cutting tools have compositions of the aforementioned groups 2, 3 and 4 are efficient. However, at very high cutting speeds, in the order, or in excess of, 1000 surface feet per minute, it is found that conventional cutting tool compositions suffer from limitations and as a result provide a short working life. This is particularly the case when the workpiece is of a high creep strength material where high temperature at the cutting edge, and high stress levels are associated with chemical and metallurgical reactions and

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combinations of the workpiece material and the cutting tool. In such situations the life of cutting tools having conventional sintered compositions is of such low value that machining costs become exceptionally high. It has been known for some time that the provision of a cutting tool capable of resisting the aforementioned conditions encountered at very high cutting speeds will mark a considerable advance in the art of cutting tools. It has further been known that the use of cobalt as a metallic binder in a cutting tool of sintered composition imposes a limit to the stress and temperature levels that may be reached without plastic deformation of the cutting tool. The use of metals such as chromium, molybdenum or alloys of nickel and molybdenum as the metallic binder in cutting tools having a sintered composition suffer from the same drawback as that of cobalt. Drawbacks have also been found in attempts to employ the refractory metals titanium, zirconium, niobium, vanadium, hafnium and tantalum in that they are in themselves carbide forming elements and can result in excessive brittleness for increases in hot strength of the cutting tool. Furthermore, at high working temperatures, cutting tools having the aforementioned sintered compositions can suffer from oxidation which may drastically shorten the working life of the cutting tool. In addition situations can arise during use of the cutting tool where conventional sintered compositions fail due to their inability to resist the corrosive action of coolants or lubricants which may be employed during machining.

It is an object of the present invention to provide a cutting tool having at least a cutting edge part of a sintered composition and which is efficient in metal machining applications and has improved wear resistance in comparison with hitherto proposed cutting tools of sintered composition.

According to the present invention there is provided a cutting tool having at least a cutting edge part of a sintered composition which consists of at least one metallic carbide selected from the group consisting of vanadium carbide, niobium carbide, hafnium carbide, zirconium carbide, tungsten carbide, titanium carbide and tantalum carbide, the metallic carbide being 70 to 96% by weight of the total composition; and a metallic binder comprising at least one metal selected from the group consisting of platinum, palladium, rhodium, and ruthenium, said selected metal or metals being 4% to 30% by weight of the total composition and at least the major part by weight of said metallic binder comprising ruthenium.

Further according to the present invention there is provided a cutting tool having at least a cutting edge part of a sintered composition having a hardness greater than 1200 V.P.N. and which sintered composition comprises at least one metallic carbide selected from the group consisting of vanadium carbide, niobium carbide, hafnium carbide, tungsten carbide, zirconium carbide, titanium carbide and tantalum carbide, the metallic carbide being 70% to 96% by weight of the total composition; and a metallic binder comprising at least one metal selected from the group consisting of platinum, palladium, rhodium and ruthenium, said selected metal or metals being 4% to 30% by weight of the total composition and at least the major part by weight of said metallic binder comprising ruthenium.

Preferably the metal or metals selected are at least 60% by weight of the metallic binder. Although the selected metal or metals are restricted to the range 4% to 30% by weight of the composition, to provide a cutting tool for general metal machining purposes, the selected metal or metals are preferably in the range 9% to 25% by weight of the composition. It has been found that as the percentage of the selected metal or metals drops below 9% and approaches 4% by weight of the composition, the cutting tool becomes extremely hard, in the order of 2,400 V.P.N. and tends towards a reduced impact resistance. Conversely as the percentage of the selected metal or metals increases above 25% and approaches 30% by weight of the composition, the sintered hardness of the cutting tool reduces whilst its impact resistance increases. Below 4% of the selected metal or metals the resultant cutting tool is found to be of insufficient toughness to have commercial value for metal machining purposes. Conversely, if the proportion of the selected metal or metals increases above 30% the resultant cutting tool has been found to possess insufficient abrasion resistance and hardness to be of commercial value for metal machining purposes.

The selected metal may be wholly ruthenium, but a combination of ruthenium and palladium may be used provided that the ruthenium is present as a larger percentage than the palladium.

In addition to the selected metal or metals, the metallic binder can include an additional metal which may be any one, or a combination of, iridium, osmium, nickel, cobalt and iron.

The metallic carbide is preferably tungsten carbide or titanium carbide or a combination of tungsten carbide and titanium carbide. The tungsten carbide may be present as a larger percentage than the titanium carbide or vice versa. Alternatively the metallic carbide may be a combination of titanium carbide, tungsten carbide and tantalum carbide and in such case the tungsten carbide is preferably at least 50% by weight of the metallic carbide and the tantalum carbide is preferably less than

30% by weight of the composition. The metallic carbide may also be a combination of titanium carbide and tantalum carbide or of tungsten carbide and tantalum carbide but again the tantalum carbide is preferably less than 30% by weight of the composition.

In deriving the present invention, it was necessary to study the high temperature behaviour of a conventional cobalt bonded hard metal composition in contact with a high creep resistant alloy. In addition, the alloying behaviour of the aforementioned metal carbides with the platinum group metals was also studied. Under conditions of elevated temperatures and pressures similar to those expected at a cutting tool and workpiece interface during high speed machining, extensive alloying through diffusion was observed by the cobalt binder with the workpiece. From studies of the behaviour of the platinum group metals it was possible to isolate the metal ruthenium, and ruthenium in combination with palladium as forming stable and workable systems of very high sintering activity with carbides of the metals tungsten, tantalum and titanium. Platinum and rhodium were found to behave in a similar manner but possessed slightly less activity in sintering than ruthenium and palladium.

In testing the high temperature behaviour of the cutting tool having a composition in accordance with the present invention under similar conditions to the aforementioned conventional cobalt bonded hard metal composition with a high creep resistant alloy, it was determined that alloying of the cutting tool composition (in accordance with the invention) with the high creep resistant alloy was minimal.

By use of conventional techniques which are well known in the art of powder metallurgy, the aforementioned carbides may be bonded together to form a dense, very hard composition. The use of ruthenium or ruthenium and the other selected metal or metals as the metallic binder in accordance with the present invention affords the considerable advantage of providing a binder, the melting point of which is considerably in excess of that previously considered practical for such bonding applications. However, the hard composition formed by such bonding techniques was found to possess unexpected properties which afforded considerable advantages in use of the composition as a cutting tool in comparison with previously proposed sintered compositions for cutting tools. Firstly, by use of the selected metal ruthenium as the metallic binder, it was found that the system formed had an unexpectedly higher sintering activity than thought possible and was therefore capable of sintering to a dense, substantially pore-free composite at temperatures as low as 1000°C below the melting point of ruthenium. It was further found that a cutting tool in accordance with the present invention having ruthenium as its metallic binder possessed very high hardness that is readily controllable by alteration of the percentage of the selected metal for the metallic binder in the composition. This high hardness can be about 2,400 V.P.N. and allied with it is an unexpected toughness which makes cutting tools of these compositions particularly suitable for high speed machining purposes. When starting with ruthenium as the metallic binder it is found that the addition of other of the selected metals, palladium, platinum or rhodium, or of the additional metals iridium, osmium, nickel, cobalt or iron, have the effect of modifying the sintered hardness and the final toughness of the sintered composition. In general the addition of palladium, nickel and cobalt will have the effect of increasing the toughness and reducing the hardness of the sintered cutting tool.

By way of example, Figure 2 of the accompanying illustrative drawings shows the relation between Vickers hardness (V.P.N.) and metallic binder content (as a percentage by weight of the composition) in a cutting tool sintered composition in which the metallic binder consists of 67% ruthenium and 33% palladium and the metallic carbide consists of tungsten carbide. Figure 3 of the accompanying illustrative drawings shows the relationship between Vickers hardness (V.P.N.) and the ruthenium to palladium ratio in the metallic binder for two sintered cutting tool compositions containing 9% and 12% (by weight of the compositions) total binder content respectively; the metallic carbide consisting of tungsten carbide. From Figure 3 it will be seen that a cutting tool having a sintered composition which consists of tungsten carbide and ruthenium, the hardness decreases from 2,200 V.P.N. for 9% of ruthenium to 1,940 V.P.N. for 12% of ruthenium. However, if one half of the ruthenium content is replaced by palladium the respective harnesses become 2,040 V.P.N. and 1,850 V.P.N. Whilst the metallic binder can consist of ruthenium or ruthenium and one or more of the metals platinum, palladium and rhodium, the additional metal or metals of the group iridium, osmium, nickel cobalt and iron are preferably present only in proportions up to 40% by weight of the metallic binder.

In general the coefficient of thermal expansion and the thermal conductivity of the selected metal or metals of the cutting tool compositions in accordance with the present invention are found to be more suitable for use in cutting tools, particularly to withstand temperature fluctuations during machining operations, than conventional metallic binders which consist of cobalt or nickel as above mentioned and comparisons between the metallic binders are shown in table 1.

TABLE 1

	Coefficient of linear Thermal Expansion (millionths' per deg. C)	Thermal conductivity at 20°C c.gs units
Cobalt	12.36	0.14
Nickel	13.46	0.142
Ruthenium	9.6	0.24
Palladium	12.4	0.168

Although the sintered cutting tool of the present invention necessarily has a high hardness, a most unexpected and advantageous contributory factor to the suitability of the compositions of the cutting tool for machining is an effect which has been observed on sintering the component materials of the tool. This is that at least ruthenium and palladium have the effect of entirely suppressing grain growth and, in some instances, actively reducing the grain size of the metal carbides during sintering. Table 2 (see below) indicates the mean grain sizes of metallic carbide constituents added as powders in comparison with their mean grain size in the sintered cutting tool of the present invention. In addition, Table 2 shows a comparison with similar metallic carbide constituents in a conventional cobalt bonded sintered cutting tool.

TABLE 2

Binder Metal	Metallic Carbide (mean Grainsize in Microns)					
	Tungsten Carbide		Titanium Carbide		Tantalum Carbide	
	Initial Powder Grainsize	Sintered Grainsize	Initial Powder Grainsize	Sintered Grainsize	Initial Powder Grainsize	Sintered Grainsize
Ruthenium or Ruthenium and Palladium	6	2—3	4	2—3	3	1½—2
	2	*				
Cobalt	6	6½—7	4	5	3	3½
	2	2—2½				

* not resolvable in matrix from other constituents.

In addition to the general improvements in hardness afforded by the cutting tool of the present invention, such tools have the further and considerable advantage that they possess markedly improved hot hardness over conventional sintered tools as will be evidenced from machining performance examples (see below). Further due to the chemical nature of the selected metal or metals in or as the metallic binder, greatly improved oxidation resistance and corrosion resistance is evident. In addition, when the cutting tool is a sintered composition which consists of one or more of the specified carbides and ruthenium (or ruthenium and one or more of the metals palladium, platinum or rhodium), the resultant material is non-magnetic; in certain applications of cutting this property may be of considerable importance, for example, when the cutting tool is itself a twist drill intended for drilling electrical circuit boards or the like which may be influenced by magnetic materials.

The mean grain sizes of the metallic car-

bides from which the cutting tool is sintered are preferably in the range 1 to 10 microns. If required the metallic carbide constituent may be initially added as a mixed crystal or solid solution powder containing two or more of the carbide metal elements.

We will now consider, by way of example only, four suitable compositions for cutting tools in accordance with the present invention in which the percentages of the constituents are by weight of the composition:—

Example 1

Ruthenium	12%	Tungsten Carbide	42%
Titanium Carbide	40%	Tantalum Carbide	6%

Example 2

Ruthenium	6%	Tungsten Carbide	39%
Palladium	3%	Titanium Carbide	40%
		Tantalum Carbide	12%

Example 3

Ruthenium	12%	Palladium	6%
Tungsten Carbide	30%	Titanium Carbide	40%
Tantalum Carbide	12%		

Example 4

Ruthenium	9%	Palladium	6%
Tungsten Carbide	39%	Titanium Carbide	40%
Tantalum Carbide	6%		

In manufacturing cutting tools from the constituents given in each of the above examples, that is to say, having a metallic binder greater than 5%, the constituents are inserted as metal powders having a grain size about 5 to 8 microns in a stainless steel mill. High purity graphite is then added to the constituents to adjust free carbon in the charge to approximately 0.1% of the weight of the charge. The charge is ball-milled wet in an organic solvent, for example, hexane, acetone, or benzene, to prevent oxidation and to aid milling, for periods of up to three days. After milling, the solvent is carefully evaporated under reduced pressure at a low temperature and approximately 2 to 4% by weight of the charge of paraffin wax is added as a temporary binder. The compositions are now pressed at approximately ten tons per square inch into compacts of convenient form for the cutting tool and such compacts pre-sintered or de-waxed at 950°C under a reducing atmosphere of, for example, hydrogen or cracked ammonia. Sintering is then conducted under a pressure of 1 Torr of argon at temperatures ranging from 1500 to 1650°C depending upon the composition. These final sintering temperatures are held for periods of one hour.

For the manufacture of cutting tools in accordance with the present invention and having compositions containing less than 5% of metallic binder (none of which are included in the aforegoing examples), the compacts are preferably prepared from the ball milled powder by a technique which is well known in powder metallurgy as hot pressing. In this, the powder is subjected simultaneously to a temperature similar to those previously cited for sintering and a pressure in the order of 1 to 2 tons per square inch.

The sintered compacts should be of a shape and size as near to, or the same as the required cutting tool, but if necessary final shaping or sizing can be achieved by use of a diamond cutter or by an electrolytic machining technique, for example, to shape a twist drill cutting tool from a cylindrical rod of the sintered composition.

By the above described process of pressing and sintering, cutting tool specimens were prepared for each of the compositions in the aforegoing examples. Each such cutting tool was in the form of an indexible machining insert intended to be clamped in a tool holder of a lathe. The inserts were of rectangular form and measured $\frac{1}{2}''$ by $\frac{1}{2}''$ by $\frac{1}{8}''$. These inserts were then tested for machinability on cutting a rotating workpiece of E.N.9 steel of 200 V.P.N. In each test the feed of the cutting tool was 0.005 inches per revolution of the workpiece, the depth of cut 0.05 inches and no coolent was applied. The machinability data obtained from cutting tools having the compositions given in Examples 1 to 4 were compared with machinability data obtained under identical cutting conditions of two commercially available cutting tools, one being a premium steel cutting grade (b) in Table 3) and the other being of a sintered composition consisting essentially of titanium carbide with a nickel, molybdenum metallic binder (a) in Table 3). Comparisons between the machinability data are shown in Table 3.

TABLE 3

Cutting Tool Composition	Hardness (V.P.N.)	Cutting Time (Minutes)	Flank Wear (Inches)	Crater Wear (Inches)
As above Example 1	1940	8	0.008	0.0002
As above Example 2	2090	8	0.008	0.0003
As above Example 3	1690	8	0.0065	0.0002
As above Example 4	1740	8	0.008	0.0002
Conventional				
a) Molybdenum 11.5%; Nickel 11.5% Cobalt 2% Tungsten Carbide 15% Titanium Carbide 60%	1800	8	0.016	0.002
b) Tungsten Carbide based premium steel cutting grade bonded with cobalt (60.5% Tungsten carbide 12% Tantalum carbide 17.5% Titanium Carbide 10% Cobalt)	1600	2	0.020	0.003

It should be noted that the figures recorded for the crater wear on the cutting tools having compositions in examples 1 to 4 are so small that, in fact, they approach that of the uneveness of the initially ground rake faces.

Accurate measurement of the contours in surface finish of the cutting tools can be made by several means well known in the art as, for example, a machine known by the Registered Trade Mark "Taly-surf" which produces amplified traces of surface irregularities. Figure 4 of the accompanying drawings illustrates in a comparative manner two such traces of which part A shows the crater wear at the cutting edge part of a cutting tool in accordance with the present invention and having a sintered composition as given in Example 4 and part B similarly shows the crater wear on the conventional premium steel cutting grade of composition b) in Table 3. The cutting edge part of the cutting tool in Figure 4A had machined for eight minutes at 1000 surface feet per minute at 0.050 inch depth of cut with 0.005 inch per revolution feed. The premium steel grade cutting tool in Figure 4B had machined under identical conditions for a period of only two minutes.

During machining the built-up edge which may be produced is formed rapidly and then remains stable until failure of the cutting edge part occurs. Figure 5 of the accompanying drawings illustrates typical comparative surface measurement traces of the stable built-up edge formed early in machining, Figure 5, part A being for the cutting tool in accordance with the present invention and having the composition in Example 4 and part B being for the conventional premium steel grade cutting tool having the composition given at b) in Table 3. It will be evident that after identical machining by the two cutting tools, although considerable built-up edge has formed on the conventional cut-

ting tool, no similar build-up occured on the tool of the present invention.

On both Figures 4 and 5 the relative horizontal and vertical scales of the surface traces are shown.

Under the comparative metal machining conditions above described, the surface finish of the workpiece can be measured and expressed as a centre line average in micro inches. The conventional premium steel cobalt bonded grade and the titanium carbide, nickel molybdenum bonded cutting tools recorded figures of 22 and 17 respectively whereas cutting tools in accordance with the present invention, particularly having the compositions *in Examples 1 to 4, have produced surface* finishes in the order of 7 micro inches. This represents a considerable improvement on previously available cutting tools. Translating the aforegoing machining figures into terms of metal removal it is found that the material increases removal rates by a factor of approximately 4 for an equivalent wear and surface finish in comparison with conventional cobalt bonded steel grade cutting tools.

It is to be understood that whenever compositions are referred to herein such compositions may include normal impurities and it is also to be understood that the compositions of the cutting tool materials in accordance with the present invention may include uncombined carbon as is well known in the art. Generally such uncombined carbon will not exceed 0.6% by weight of the composition.

WHAT WE CLAIM IS:—

1. A cutting tool having at least a cutting edge part of a sintered composition which consists of at least one metallic carbide selected from the group consisting of vanadium carbide, niobium carbide, hafnium carbide, zirconium carbide, tungsten carbide, titanium carbide and tantalum carbide, the metallic carbide being 70% to 96% by weight of the total composition; and a metallic binder comprising at least one metal selected from the group consisting of platinum, palladium, rhodium and ruthenium, said selected metal or metals being 4% to 30% by weight of the total composition and at least the major part by weight of said metallic binder comprising ruthenium.

2. A cutting tool having at least a cutting edge part of a sintered composition having a hardness greater than 1200 V.P.N. and which sintered composition comprises at least one metallic carbide selected from the group consisting of vanadium carbide, niobium carbide, hafnium carbide, tungsten carbide, zirconium carbide, titanium carbide and tantalum carbide, the metallic carbide being 70% to 96% by weight of the total composition; and a metallic binder comprising at least one metal selected from the group consisting of platinum, palladium, rhodium, and ruthenium, said selected metal or metals being 4% to 30% by weight of the total composition and at least the major part by weight of said metallic binder comprising ruthenium.

3. A cutting tool as claimed in either claim 1 or claim 2 in which said selected metal or metals is at least 60% by weight of the metallic binder.

4. A cutting tool as claimed in any one of the preceding claims in which said selected metal or metals are 9% to 25% by weight of the composition.

5. A cutting tool as claimed in any one of the preceding claims in which said selected *metal consists of ruthenium and palladium.*

6. A cutting tool as claimed in any of the preceding claims wherein the metallic binder includes an additional metal or metals selected from the group consisting of iridium, osmium, nickel, cobalt and iron.

7. A cutting tool as claimed in any one of the preceding claims wherein the metallic carbide consists of at least one carbide selected from tungsten carbide and titanium carbide.

8. A cutting tool as claimed in claim 7 wherein the metallic carbide consists of tungsten carbide and titanium carbide and the tungsten carbide is at least 50% by weight of the metallic carbide.

9. A cutting tool as claimed in any one of claims 1 to 6 wherein the metallic carbide consists of tungsten carbide, titanium carbide and tantalum carbide.

10. A cutting tool as claimed in claim 9 in which the tungsten carbide is at least 50% by weight of the metallic carbide.

11. A cutting tool as claimed in either claim 9 or claim 10 in which the tantalum carbide is less than 30% by weight of the total composition.

12. A cutting tool as claimed in any one of claims 1 to 6 wherein the metallic carbide consists of tungsten carbide and tantalum carbide.

13. A cutting tool as claimed in any one of claims 1 to 6 where the metallic carbide consists of titanium carbide and tantalum carbide.

14. A cutting tool as claimed in either claim 12 or claim 13 wherein the tantalum carbide is less than 30% by weight of the composition.

15. A cutting tool as claimed in any one of the preceding claims in which the metallic carbide or carbides from which the composition is sintered have a mean grain size of 1 to 10 microns.

16. A cutting tool as claimed in any one of the preceding claims and containing uncombined carbon in an amount not exceeding 0.6% by weight of the composition.

17. A cutting tool as claimed in claim 16 wherein substantially 0.1% by weight of the composition is uncombined carbon.

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18. A cutting tool having at least a cutting edge part of a sintered composition substantially as herein described and with reference to Example 1.

19. A cutting tool having at least a cutting edge part of a sintered composition substantially as herein described and with reference to Example 2.

20. A cutting tool having at least a cutting edge part of a sintered composition substantially as herein described and with reference to Example 3.

21. A cutting tool having at least a cutting edge part of a sintered composition substantially as herein described and with reference to Example 4.

22. The combination of a tool holder or tool body and a cutting tool as claimed in any one of the preceding claims.

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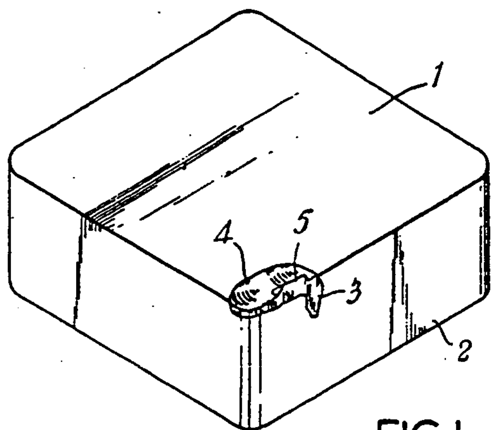


FIG.1

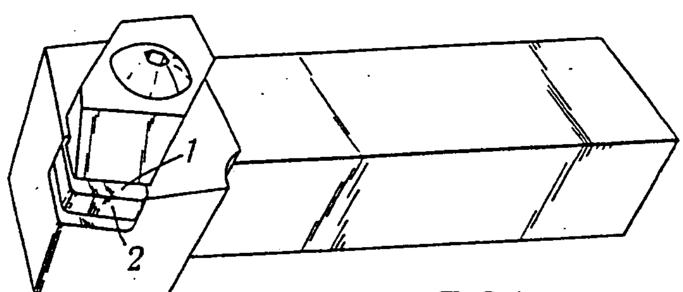


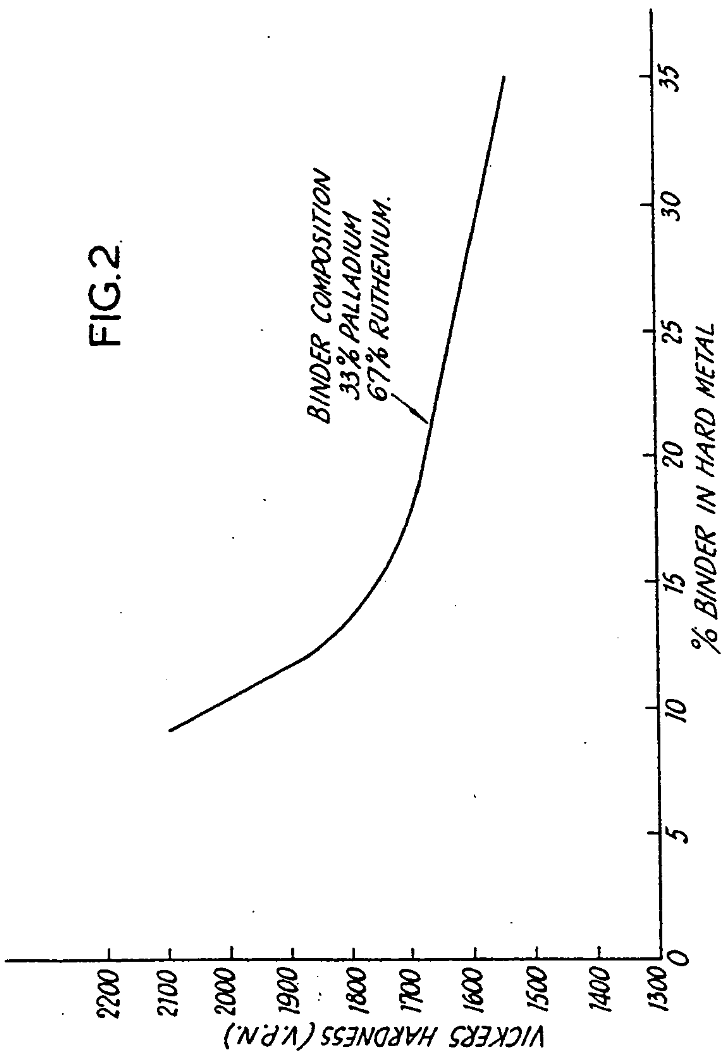
FIG.1A

1309634 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG.2

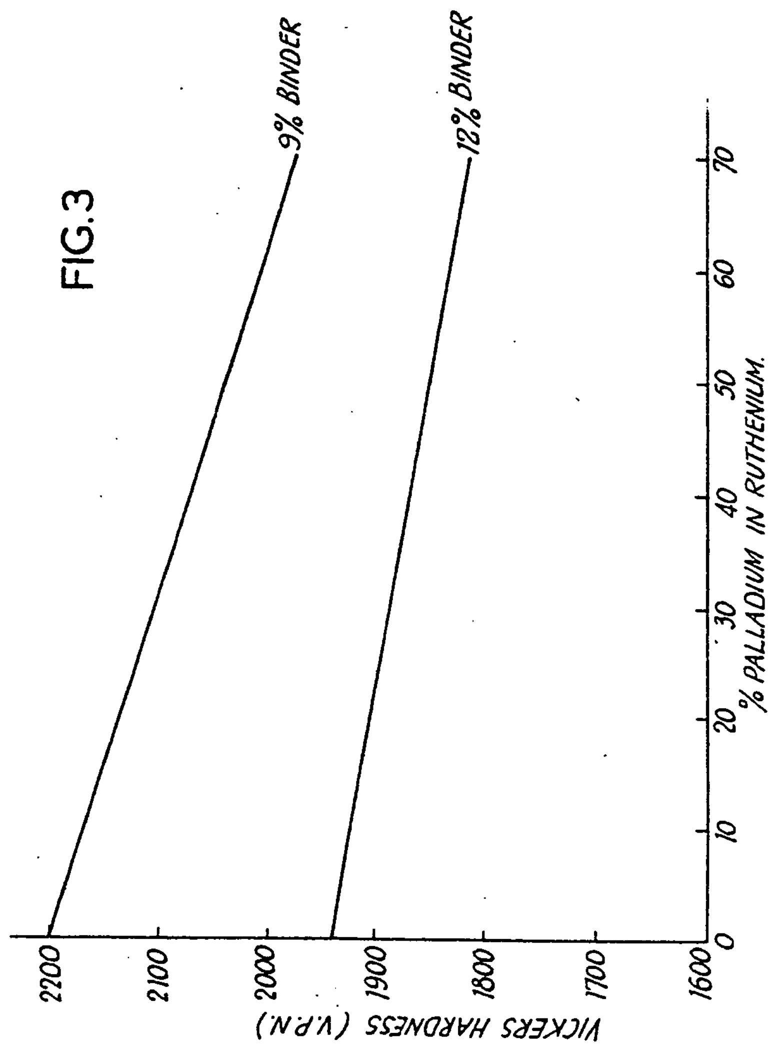


1309634 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG.3



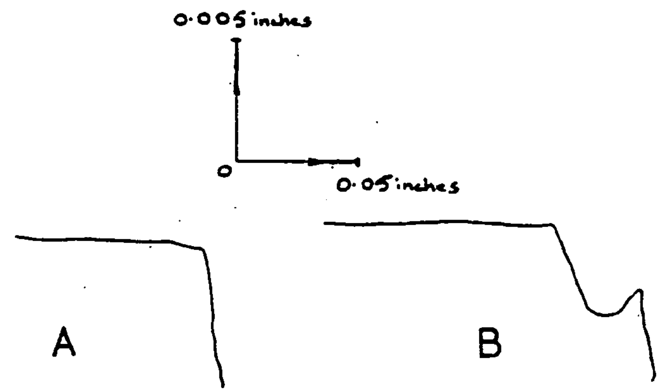


FIG.4

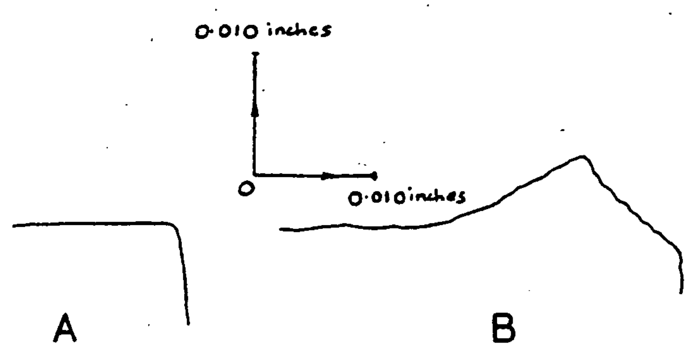


FIG.5